THE NEUROMUSCULAR BUNDLES (MUSKELKNOSPEN, MUSKELSPINDELN, FAISCEAUX NEURO-MUSCULAIRES).[1]

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The excellent state of preservation of the neuromuscular bundles in a case of intense muscular dystrophy studied microscopically by the author seems of sufficient importance to warrant a brief statement, especially as very little has appeared in the English literature on this subject.

The case was one of intense muscular atrophy with contractures; it was from the clinic of Prof. Dejerine at the Bicêtre, Paris, and has been referred to by him in his lectures. No lesions were found in the spinal cord which could in any way explain the amyotrophy, for the ganglion cells were well formed and were about normal in number. The deltoid muscle, of one side at least, was so intensely atrophied that it appeared more like a portion of the diaphragm, and when examined microscopically, was found to be almost entirely composed of connective tissue. In a few sections from this muscle, in one portion of the field, a single group of hypertrophied muscular fibres could be seen, which had undergone hyaline degen-

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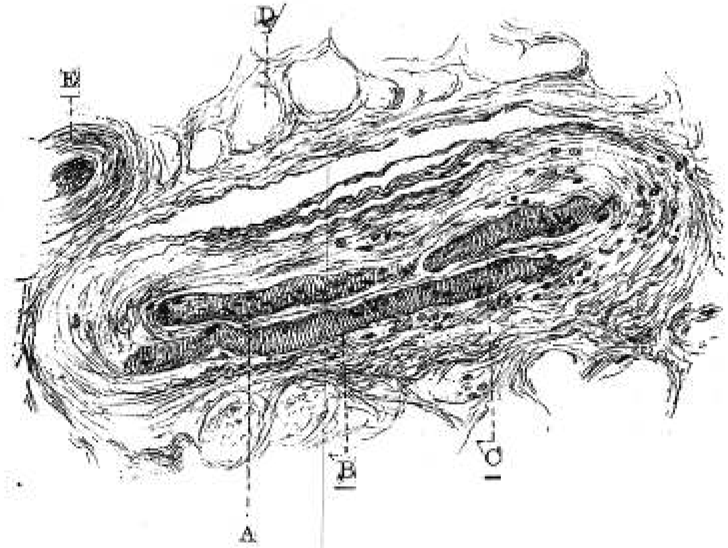
[1] This case was reported and the specimens were exhibited at a meeting of the Philadelphia Neurological Society in 1896. The paper was already in type when the work of Batten on the neuromuscular bundles (Brain, Parts LXXVII. and LXXVIII., 1897) came into the hands of the writer.

eration and longitudinal segmentation, as described by Erb. Elsewhere it was impossible to find anything which in any way resembled muscular tissue, except in the neuromuscular bundles. The intramuscular vessels were much thickened, but the small intramuscular nerves were apparently perfectly normal. The medullary sheaths of these nerves, when stained by the method of Weigert, had the appearance of normal fibres, and when the carmin was



Longitudinal section of a neuromuscular bundle.
A B C, small muscular fibres within the bundle. D, fatty connective tissue which has replaced the surrounding muscular tissue. E, small intramuscular vessels with greatly thickened coats.

employed the axis cylinders were distinctly seen. In some microscopic fields two neuromuscular bundles could be seen, whereas in others not a single one could be found. It has been possible to obtain several good longitudinal sections of these structures, and in one section a bundle was cut in such a manner that it afforded a transverse and longitudinal view of the same muscular fibres; a result which was due to a curving of the bundle. The external sheath was very thick in comparison with the intramuscular nerve sheaths, and within this were found connective tissue rich in nuclei, and one or two delicate muscles cut longitudinally. The nuclei of the muscular fibres were slightly elongated and quite numerous, but they did not appear to be more abundant in the centre of the fibres. In the picture of a longitudinal section, published with this paper, it may be seen that these muscles are of considerable length for such delicate structures; that they are of less diameter than are ordinary muscular fibres, and that they are transversely striated. The state of preservation of the fibres as compared with that of the surrounding muscle is most striking.

Excellent pictures of *transverse* sections of neuromuscular bundles have been published, and two especially good are to be found in an article on neuritis, by Babinski. (²) Laura Forster (³) has carefully studied these bodies, and is able to refer to quite an extensive literature on the subject. According to her statements, Weismann (⁴) was the first to note their existence. Koelliker (⁵) described them in 1862 as *"Nervenknospen,"* a name which he has now changed to *"Muskelknospen."*

Among other investigators may be mentioned Aeby, Kühne, Ranvier, Krause, Bremer, Mays, Kerschner, Blocq, Marinesco, and Sherrington.

Babinski (⁶) believed he was the first to describe the neuromuscular bundles as found in man, although Roth had already reported to the Medical Society of Moscow the results of his investigations in this field. Kerschner and Felix showed that the neuromuscular bundles of Roth

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[2] Babinski: Traité de Médecine, VI., p. 704.

[3] Laura Forster: Virchow's Archiv, 1894; 137. p. 121.

[4] Weismann: Zeitschrift für rationelle Medicin, 1861, Vol. X., p. 263.

[5] Koelliker: Gewebelehre, Vol. I., p. 394.

[6] Babinski: Comptes rendus hebdomadaires des séances de la Société de Biologie, 1886, p. 629; and Archives de Médecine Expérimentale, 1889, p. 416.

and Babinski, found in man, are the same as the muscle spindles of the German writers, found in animals.

Weiss and Dutil (⁷) describe the nerve fibre of the neuromuscular bundle as terminating by free ramifications, some of which embrace the large nuclei of these small muscles. At the enlargement of each muscular fibre is a group of nuclei two or three times the size of the nuclei of ordinary muscles, and at this part the muscular striation usually ceases; in other parts of the fibre scattered nuclei are found.

Weiss and Dutil employed the chlorid of gold in their investigations. They found the neuromuscular bundles especially numerous near the tendons, and they state that in some cases it may only be possible to distinguish them from the corpuscles of Golgi by the transverse striations. The same nerve differing, as regards size, number of nodes, and thickness of the sheath of Henle, from the ordinary nerve of the surrounding muscle, sends branches to the neuromuscular bundle and the organ of Golgi. The muscular bundles contain motor plates, similar to the motor terminations in the ordinary muscle, and this fact they think proves the power of contractility of these small fibres.

Comparatively few histologists of the present day hold the opinion, once quite prevalent, that these bundles are pathologic, for, as Sihler (⁸) justly remarks, their construction is so evidently adapted to some special function that any such view is improbable. Some have held that they are ordinary muscular fibres in the process of formation, although no one has shown the intermediate stages; others that they indicate retrograde change. Kerschner (⁹), Pilliet (¹⁰), Laura Förster, and others, have ascribed

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[7] Weiss and Dutil: Archives de Physiologie, April, 1896.

[8] Sihler: Archiv für mikroskopische Anatomie, 1895, 45, p. 709.

[9] Kerschner: Anatomischer Anzeiger, 1888, 1893.

[10] Pilliet: Comptes rendus hebdomadaires des séances de la Société de Biologie, 1890, p. 313.

to them a sensory function, and Weiss and Dutil have expressed themselves in favor of this view. This function seems to stand in some special relation to the muscular sense. Golgi has thought that they are connected with the lymphatic system.

Roth ([11]) has found these bodies in progressive muscular atrophy and other diseases; Pilliet has studied them in alcoholic paraplegia, chronic rheumatism and amyotrophic lateral sclerosis; Blocq and Marinesco ([12]) in poliomyelitis and polyneuritis; Eichhorst ([13]) in neuritis; Laura Forster in myelitis; in a case of progressive muscular atrophy in which no definite lesions were found in the cord, and in bulbar paralysis. Professor Dejerine has kindly called the writer's attention to the fact that Roth, in his large work on muscular atrophy, published in Russian, speaks of them again in primary atrophic myopathy.

The more intense the atrophy, the more distinct these bundles become, and in the case of atrophy from myelitis, reported by Laura Forster, in which many nerves were degenerated and the muscles were almost entirely destroyed, these bundles were well preserved.

Whatever may be the opinion in regard to the nature of these bundles, it is well worthy of note that in complete degeneration of muscular dystrophy, when the intramuscular nerve fibres appear normal, these neuromuscular bundles may undergo no notable change.

The pleasant duty of thanking Professor Dejerine for the pathologic material and for many manifestations of kindness is gladly discharged by the writer.

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[11] Roth: Centralblatt für die medicinischen Wissenschaften, 1887, p. 129.

[12] Blocq and Marinesco: Comptes rendus hebdomadaires des séances de la Société de Biologie, 1890, p. 398.

[13] Eichhorst: Virchow's Archiv, 1888, CXII.